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ATTORNEY DOCKET NO. 9775-0031-999

Date: March 8, 2000

Assistant Commissioner for Patents
Box PATENT APPLICATION
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Sir:

The following utility patent application is enclosed for filing:

Applicant(s): LEWIS B. ARONSON and DANIEL S. KANE

Executed on: March 7, 2000

Title of Invention: FIBER OPTIC LASER TRANSMITTER WITH REDUCED NEAR END REFLECTIONS

PATENT APPLICATION FEE VALUE

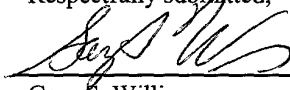
TYPE	NO. FILED	LESS	EXTRA	EXTRA RATE	FEE
Total Claims	23	-20	3	\$18.00 each	\$ 54.00
Independent	2	-3	0	\$78.00 each	\$ 0.00
Minimum Fee					\$ 690.00
Multiple Dependency Fee If Applicable (\$260.00)					\$ 0.00
Total					\$ 744.00
50% Reduction for Independent Inventor, Nonprofit Organization or Small Business Concern (a verified statement as to the applicant's status is attached)					\$ 372.00
Total Filing Fee					\$ 372.00

Also enclosed are:

- XX 6 sheets of formal drawings;
- XX Declaration;
- XX Assignment and PTO Form 1595;
- XX Power of Attorney by Assignee; and
- XX Verified Statement Claiming Small Entity.

Please charge the required fee to Pennie & Edmonds LLP Deposit Account No. 16-1150 (9775-0031-999). A copy of this sheet is enclosed for such purpose.

Respectfully submitted,



Gary S. Williams
PENNIE & EDMONDS LLP

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(Reg. No.)

Enclosure

This form is not for use with continuation, divisional, re-issue, design or plant patent applications.

Applicant or Patentee: Lewis B. Aronson Attorney's Docket No.: 9775-0031-999

Serial or Patent No.: _____

Filed or Issued: _____

For: FIBER OPTIC LASER TRANSMITTER WITH REDUCED NEAR END REFLECTIONS

VERIFIED STATEMENT (DECLARATION) CLAIMING SMALL ENTITY
STATUS (37 CFR 1.9(f) and 1.27(c)) - SMALL BUSINESS CONCERN

I hereby declare that I am

☐ the owner of the small business concern identified below:

☒ an official of the small business concern empowered to act on behalf of the concern identified below:

NAME OF CONCERN: FINISAR CORPORATION

ADDRESS OF CONCERN: 1308 MOFFETT PARK DRIVE, SUNNYVALE, CA 94089-1133

I hereby declare that the above identified small business concern qualifies as a small business concern as defined in 13 CFR 121.3-18, and reproduced in 37 CFR 1.9(d), for purposes of paying reduced fees to the Patent and Trademark Office under Section 41(a) and (b) of Title 35, United States Code, in that the number of employees of the concern, including those of its affiliates, does not exceed 500 persons. For purposes of this statement, (1) the number of employees of the business concern is the average over the previous fiscal year of the concern of the persons employed on a full-time, part-time or temporary basis during each of the pay periods of the fiscal year, and (2) concerns are affiliates of each other when either, directly or indirectly, one concern controls or has the power to control the other, or a third party or parties controls or has the power to control both.

I hereby declare that rights under contract or law have been conveyed to and remain with the small business concern identified above with regard to the invention entitled FIBER OPTIC LASER TRANSMITTER WITH REDUCED NEAR END REFLECTIONS by inventor(s) Lewis B. Aronson and Daniel S. Kane described in:

☒ the specification filed herewith

☐ application serial no. _____, filed _____

☐ patent no. _____, issued _____

If the rights held by the above identified small business concern are not exclusive, each individual, concern or organization having rights to the invention is listed below* and no rights to the invention are held by any person, other than the inventor, who could not qualify as a small business concern under 37 CFR 1.9(d) or by any concern which would not qualify as a small business concern under 37 CFR 1.9(d) or a nonprofit organization under 37 CFR 1.9(e). *NOTE: Separate verified statements are required from each named person, concern or organization having rights to the invention averring to their status as small entities. (37 CFR 1.27)

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☐ Individual ☐ Small Business Concern ☐ Nonprofit Organization

I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate. (37 CFR 1.28(b)).

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this verified statement is directed.

NAME OF PERSON SIGNING Jerry Rawls

TITLE IN ORGANIZATION Chief Executive Officer

ADDRESS OF PERSON SIGNING 1308 Moffett Park Drive, Sunnyvale, CA 94089-1133

SIGNATURE Jerry Rawls

DATE March 7, 2000

FIBER OPTIC LASER TRANSMITTER WITH REDUCED NEAR END REFLECTIONS

Inventors: Lewis B. Aronson, Daniel S. Kane

The present invention relates generally to laser based fiber optic transmission systems, and particularly to apparatus for reducing near end reflections from the near fiber end face back into the laser cavity.

5

BACKGROUND OF THE INVENTION

Referring to Fig. 1, there is shown a somewhat simplified representation of a conventional laser based fiber optic transmission system 50. The transmitter's laser 52 is a diode laser that is housed in a hermetically sealed transistor outline (TO) can 54, herein called the laser housing or the TO-can. The laser housing includes a window 56 through which emitted laser light is transmitted. Typically, a thin film antireflection coating 58 is deposited on the inside surface of the window 56 to reduce reflections from the window 56, and may also include another thin film antireflection coating 60 on the outside surface of the window 56 to reduce reflections from that surface. Each of the thin film antireflection coatings 58, 60 is a conventional optical antireflection film, typically having a thickness of a quarter wave of the transmitted laser light.

The light transmitted by the laser is focused by the lens 62 onto a front end of an optical fiber 64 for transmission through the optical fiber 64 to a receiving device 66. A portion of the light transmitted by the laser 52 is reflected back toward the laser 52 by the near and far end faces of the optical fiber 64, as well as by any other optical discontinuities such as connectors. It is well known that reflections coupled back into a laser cavity cause fluctuations in both the amplitude and phase of the laser output. These fluctuations have several detrimental effects including increased relative intensity noise (RIN), increased

spectral width, and increased mode partition noise (for multi-longitudinal mode lasers). In fiber optic communication systems each of these may have an adverse effect on system performance. The most notable manifestation is a reduction in fiber optic link length (i.e., the space between signal repeaters must be reduced to avoid loss of information). In some cases, however, the effects can be so profound as to prevent satisfactory performance altogether over even an arbitrarily short link.

A great deal of energy has been spent attempting to reduce unwanted reflections and their degrading effects. Lasers of all varieties including distributed feedback (DFB) lasers, Fabry-Perot (FP) lasers, and vertical cavity surface emitting lasers (VCSELs) are subject to the negative effects of reflections coupled back into the laser cavity. DFB and FP lasers used in single (spatial) mode links of up to 120km and more are particularly susceptible. However, the present invention can be used with other types of lasers as well.

Reflections occur wherever there is a discontinuity in index of refraction (n) within an optical link. Such discontinuities generally exist wherever a fiber ends (fiber-air interface), and wherever a connector or splice introduces a slight change in index. In the case of a connectorized link (that is, a link with a removable fiber connector on either end as opposed to one where every connection is spliced) two primary reflections are from the near and far ends of the fiber. The near end reflection results from the air/fiber discontinuity where the laser light is focused onto the fiber, and the far end reflection results from the fiber/air discontinuity where the opposite end of the fiber is plugged into a receiver.

In many cases, the near end reflection dominates all others in terms of its negative effects. In such cases, schemes to reduce the near end reflections can provide sufficient optical isolation. Referring to Fig. 2, traditionally, optical isolation in a fiber optic transmission system is obtained using a 45 degree Faraday rotator sandwiched between two linear polarizers, oriented at 45 degrees with respect to each other. The 45 degree Faraday rotator is a magneto-optical device that uses magnetic fields to rotate the polarization state of light. The combination of the two polarizers and the Faraday rotator is called an isolator.

Light propagating from the laser passes through the first polarizer 84. Its polarization state is then rotated 45 degrees by the Faraday rotator 82 so that it is parallel to the second polarizer 86. Reflected light traversing the isolator in the opposite direction, however, is first polarized by the polarizer 86 farthest from the laser. It is then rotated, by the Faraday rotator 82, 45 degrees in the same direction as if it were traversing forward through the Faraday rotator 82. The resulting polarization state is thus perpendicular to the orientation of the polarizer 84 closest to the laser 52 and therefore the reflected light is blocked. Such isolators 82, 84, 86 block all reflected light. They are essentially optical one way valves. They are extremely effective, but are also very expensive. In particular, the inclusion of the Faraday rotator 82 greatly increases the cost of the transmitter.

Another method to reduce near end reflections is shown in Fig. 3. Fig. 3 shows more of the details of a typical laser transmitter housing. This same style of housing may be used in all of the prior art transmitters as well as in the transmitters of the present systems. Since the additional details of the transmitter systems shown in Fig. 3 are not relevant to the present invention, they are not repeated in the other figures.

In the system shown in Fig. 3, the transmitter 90 contains a short length of optical fiber 92, herein called a fiber stub, that has an angled endface 94 at the end closer to the laser 52. The laser and lens are arranged such that the light from the laser is coupled efficiently into the angled end 94 of the fiber stub 92. The angled endface 94 eliminated reflection from that surface by directing the reflection away from the laser. At the other end 96 of the fiber stub 92, reflections are reduced by relying on physical contact between fiber stub and the external fiber 64 of the transmission system. The system shown in Fig. 3 has a few notable weaknesses. First and foremost, the system relies on perfect physical contact between the fiber stub 92 and the user's optical fiber 64. Even a microscopic particle on the surface of the fiber stub 92, which is usually inconvenient to clean, will eliminate physical contact and result in reflections as severe as in the uncorrected system shown in Fig. 1. Secondly, the cost of the fiber stub 92 is often significant. Finally, in some situations, the extra length imposed by the fiber stub is a significant disadvantage.

SUMMARY OF THE INVENTION

In summary, the present invention is a laser apparatus that either blocks light transmitted by a laser from being reflected back into the laser cavity, or conditions the reflected light to a linear polarization state that does not interfere with operation of the laser.

The laser apparatus, which generates laser light to be transmitted through an optical transmission system includes a laser that emits light that is substantially linearly polarized, a housing in which the laser is mounted, and a quarter wave retarder plate. The quarter wave retarder plate is disposed so that the emitted laser light passes through the quarter wave retarder plate prior to transmission of the emitted laser light through the optical transmission system. The quarter wave retarder plate causes the emitted laser light to become circularly polarized with a predefined handedness. The quarter wave retarder plate is also disposed so that light reflected by the optical transmission system back toward the laser passes through the quarter wave retarder plate a second time prior to reaching the laser, causing the reflected light to become linearly polarized with a linear polarization that is orthogonal to the polarization state of the light emitted by the laser.

In one embodiment, a linear polarizer is positioned between the laser and the quarter wave retarder plate. The linear polarizer imposes a particular linear polarization orientation on the emitted laser light, and blocks the reflected light that passes through the quarter wave retarder plate because that light has a linear polarization that is orthogonal to the polarization axis of the linear polarizer.

BRIEF DESCRIPTION OF THE DRAWINGS

Additional objects and features of the invention will be more readily apparent from the following detailed description and appended claims when taken in conjunction with the drawings, in which:

Fig. 1 depicts a laser transmitting light into an optical fiber.

Fig. 2 depicts a laser to fiber connection with a prior art near end reflection reduction apparatus.

Fig. 3 depicts another laser to fiber connection with a second prior art near end reflection
5 reduction apparatus.

Fig. 4 depicts a first embodiment of a laser to fiber connection with near end reflection reduction apparatus in accordance with the present invention.

10 Fig. 5 depicts the polarization of laser light at various positions in the system shown in Fig. 4.

Fig. 6 depicts a second embodiment of a laser to fiber connection with near end reflection reduction apparatus in accordance with the present invention.

15 Fig. 7A, 7B, 7C and 7D depict first, second, third and fourth embodiments, respectively, of a laser transmitter apparatus in accordance with the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

20 Referring to Figs. 4 and 5, there is shown a laser based fiber optic transmission system 100 having a diode laser 52 that is housed in a hermetically sealed transistor outline (TO) can 54, herein called the laser housing or the TO-can. The laser housing includes a window 56 through which the emitted laser light is transmitted. In a preferred embodiment, there is a
25 thin film antireflection coating 58 on the inside surface of the window 56 to reduce reflections from the window 56 and another thin film antireflection coating 60 is on the outside surface of the window 56 to reduce reflections from that surface. Each of the thin film antireflection coatings 58, 60 is a conventional optical antireflection film, typically having an optical thickness of a quarter wave of the transmitted laser light.

While the laser housing 54 typically is a hermetically sealed housing that has a window 56 through which the emitted laser light is transmitted, but the hermetic seal and window are not essential elements of the present invention.

5 The light transmitted by the laser 52 is focused by the lens 62 onto the front end of an optical fiber 64 for transmission through the optical fiber 64 to a receiving device 66. A portion of the light transmitted by the laser 52 is reflected back toward the laser 52 by the near and far end faces of the optical fiber 64, as well as by other optical discontinuities such as connectors.

10 A quarter wave retarder plate 102 is positioned in the light path between the laser 52 and the lens 64. More generally, the quarter wave retarder plate 102 can be placed anywhere between the laser and the end of the fiber 64 responsible for the near end reflection. However, it is typically easiest to mount the quarter wave retarder plate 102 between the laser 52 and the
15 lens 62, because the optical fiber 64 is typically removable while the lens is typically permanently mounted at a fixed location with respect to the laser 52.

20 The quarter wave retarder plate 102 can be made of crystal, polymer or other material. It can also be a higher order wave plate, although higher order wave plates have the disadvantage of being less tolerant of non-normal incident light. A quarter wave retarder plate 102 is an optical system component that is well known to those skilled in the art of designing optical systems. A quarter wave retarder plate differentially retards light passing through it, in either direction, by an odd number (e.g. 1, 3 or 5) of quarter wavelengths. The retarder plate has two principal axes, called slow and fast. The retarder plate can be thought of as resolving a
25 light beam passing through it into two polarized components, with the component parallel to the slow axis lagging the one parallel to the fast axis by an odd number of wavelengths, and then recombining the two to form a single emerging beam. When the light beam entering the retarder plate is linearly polarized at 45 degrees to the fast and slow axes, the light that emerges from the retarder plate is circularly polarized.

30 The light emitted by the diode laser 52, which is preferably a DFB or FP laser, is linearly polarized to a very high degree. The polarized light from the laser 52 passes through the

quarter wave retarder plate 102, which is oriented so that its fast axis is oriented at 45 degrees in either direction with respect to the polarization of the incident light. The linearly polarized light passing through the quarter wave plate 102, oriented as described above, emerges as either left or right handed circularly polarized light. The resulting light is focused by the lens
5 62 onto the front end of the fiber 64. A large portion of the laser light is transmitted through the optical fiber 64, while a smaller portion of the laser light is reflected by the front end of the optical fiber 64.

When circularly polarized light is reflected from a surface such as the front end of the optical
10 fiber 64, the handedness of the light's circular polarization flips from left to right or vice versa. As a result, laser light reflected by the front end of the optical fiber and transmitted back through the lens toward the laser 52 has the opposite handedness of the laser light which is traveling from the laser 52 toward the front end of the optical fiber 64.

When the reflected circularly polarized light passes through the quarter wave retarder plate
15 102 a second time, the circularly polarized light is converted back to linearly polarized light. However, the polarization state of the reflected light is now oriented orthogonal to the original polarization state of the transmitted laser light. Light of orthogonal polarization does not couple back into the laser's oscillation mode, and so it has none of the detrimental effects
20 described above, in the Background of The Invention section of this document. In this first embodiment the reflected light is not blocked. Rather, the reflected light is manipulated into a polarization state that does not couple back into the laser's oscillation mode.

Fig. 6 shows a second laser based fiber optic transmission system 120 that implements a
25 second embodiment of the present invention. Only those aspects of system 120 that differ from system 100 shown in Fig. 4 will be described.

In this second embodiment, there is a linear polarizer 104 on (i.e., adjacent to) the front face
30 of the quarter wave retarder plate 102 (i.e., on the face closest to the laser 52). Light from the laser 52, which is generally already linearly polarized, passes through the linear polarizer 104 before passing through the quarter wave retarder plate 102. When the light from the laser 52 is traveling from the laser 52 to the lens, the only effect of the linear polarizer is to impose a

particular linear polarization on the light from the laser 52. The quarter wave retarder plate 102, as before, causes the laser light traveling toward the lens 62 to become circularly polarized.

5 As in the first embodiment, light reflected by the front end of the optical fiber 64 is circularly polarized, but with the opposite handedness of the light traveling from the laser toward the front end of the optical fiber 64. When this reflected light passes through the quarter wave retarder plate 102 a second time (i.e., while traveling back toward the laser 52), the light becomes linearly polarized, but with a polarization that is orthogonal to the polarization of
10 the linear polarizer 104. As a result, the reflected light is blocked by the linear polarizer 104. This second embodiment of the present invention is useful in any system where the polarization state of the laser light remains unchanged between the lens 62 and the face of the optical fiber that is responsible for the near end reflection.

15 The second embodiment has several possible advantages over the first embodiment. First, the addition of a polarizer would be essential in any laser transmitter with an unpolarized output. Second, the added polarizer blocks any near end reflection from returning to the laser, which would be necessary if the laser was adversely affected by light not in the oscillating mode. Finally, for manufacturing reasons, it may be easier to align the polarizer
20 more accurately to the quarter wave retarder plate, for example if the polarizer and quarter wave retarder plate (sometimes called a waveplate for convenience) are laminated together in large sheets, than it is to align a quarter wave retarder plate to the polarization axis of the laser. The combined polarizer/waveplate would be much less sensitive to angular misalignment to the laser than would a separate waveplate.

25

Fig. 7A depicts a first embodiment of a laser transmitter apparatus 140 in accordance with the present invention. In this embodiment, a quarter wave retarder plate 112 forms part of the TO-can 54 housing of the laser diode 52. In particular, the quarter wave retarder plate 112 may be positioned after the TO-can window 56, as shown in Fig. 7A, so that light from the
30 laser 52 traverses the quarter wave retarder plate 112 after passing through the window 56. The quarter wave retarder plate 112 is oriented so that its fast axis is oriented 45 degrees with respect to the polarization of the incident light from the laser 52.

Alternately, the quarter wave retarder plate 112 can be positioned before the TO-can window so that light from the laser 52 traverses the quarter wave retarder plate 112 before passing through the window 56. As shown in Fig. 7C, the quarter wave retarder plate 112 can be fashioned to act as (i.e., form) the TO-can window of a laser transmitter 170. The quarter wave retarder plate can also be placed between the lens 62 and the external fiber 64 of the optical transmission system, as shown in Fig. 7D. In any such position, the quarter wave retarder plate 112 performs the same function and works in the same way as the embodiment shown in Fig. 4. In particular, as the linearly polarized light transmitted by the laser diode 52 passes through the quarter wave plate 112, oriented as described above, emerges as either left or right handed circularly polarized light.

Assuming that the system in which the laser transmitter apparatus 140 is used does not have any devices between the laser transmitter 140 and the optical fiber into which light from the laser transmitter is injected, that change the polarization state of the transmitted light, then any light reflected by the front end of the optical fiber (or any other device or interface, not shown) back into the laser transmitter 140 will have circular polarization of the opposite handedness of the light originally transmitted by the laser transmitter 140.

When the reflected circularly polarized light passes through the quarter wave retarder plate 112 a second time, the circularly polarized light is converted back to linearly polarized light. As in the embodiment shown in Fig. 4, the polarization state of the reflected light is now oriented orthogonal to the original polarization state of the transmitted laser light. Light of orthogonal polarization does not couple back into the laser's oscillation mode, and so it has none of the detrimental effects described above, in the Background of The Invention section of this document. In this embodiment, reflected light is not blocked. Rather, it is manipulated into a polarization state that does not couple back into the laser's oscillation mode.

Fig. 7B depicts a second embodiment of a laser transmitter apparatus 160 in accordance with the present invention. Only those aspects of the laser transmitter 160 that differ from the laser transmitter 120 shown in Fig. 7A will be described. In this embodiment, there is a linear polarizer 114 on (i.e., adjacent to) the front end of the quarter wave retarder plate 112

facing the laser. The polarizer 114 and the plate 112 are positioned between the window 56 and the front face 116 of the laser transmitter 160. Alternately, the quarter wave retarder plate 112 and the polarizer 114 can be positioned between the laser 52 and the TO-can window so that light from the laser 52 traverses the linear polarizer 114, and then the quarter wave retarder plate 112 before passing through the window 56.

Light from the laser 52, which is generally already linearly polarized, passes through the linear polarizer 114 before passing through the quarter wave retarder plate 112. The linear polarizer 114 imposes a particular linear polarization on the light emitted from the laser 52. The quarter wave retarder plate 112, as before, causes the laser light traveling from the laser 52 toward the front face 116 of the laser transmitter 140 to become circularly polarized with a particular, predefined handedness.

As in the embodiment of Fig. 7A, light reflected by the front end of an optical fiber (not shown) or any other device back into the laser transmitter 160 is circularly polarized, but with the opposite handedness of the light traveling from the laser 52 toward the front face 116 of the laser transmitter 160. When this reflected light passes through the quarter wave retarder plate 112 a second time (i.e., while traveling back toward the laser 52), the light becomes linearly polarized, but with a polarization that is orthogonal to the polarization of the linear polarizer 114. As a result, the reflected light is blocked by the linear polarizer 114.

The linear polarizer 114 can optionally be added to the systems shown in Figs. 7C and 7D, while in other embodiments of the systems of Figs. 7C and 7D the linear polarizer is not included.

Alternate Embodiments

While the present invention has been described with reference to a few specific embodiments, the description is illustrative of the invention and is not to be construed as limiting the invention. Various modifications may occur to those skilled in the art without departing from the true spirit and scope of the invention as defined by the appended claims.

WHAT IS CLAIMED IS:

- 1 1. Laser apparatus for generating laser light to be transmitted through an optical
2 transmission system, comprising:
3 a laser that emits light that is substantially linearly polarized; and
4 a quarter wave retarder plate, disposed with respect to the laser so that the emitted
5 laser light passes through the quarter wave retarder plate prior to transmission of the emitted
6 laser light through the optical transmission system, the quarter wave retarder plate causing the
7 emitted laser light to become circularly polarized with a predefined handedness;
8 wherein the quarter wave retarder plate is also disposed so that light reflected by the
9 optical transmission system back toward the laser passes through the quarter wave retarder
10 plate prior to reaching the laser, the quarter wave retarder plate causing the reflected light to
11 become linearly polarized with a polarization that is orthogonal to the emitted laser light
12 emitted by the laser.
- 1 2. The laser apparatus of claim 1, further including a lens disposed between the laser and
2 the optical transmission system, wherein the quarter wave retarder plate is disposed between
3 the laser and the lens.
- 1 3. The laser apparatus of claim 2, further including a linear polarizer disposed between
2 the laser and the quarter wave retarder plate.
- 1 4. The laser apparatus of claim 3, wherein the linear polarizer is adjacent a surface of the
2 quarter wave retarder plate that faces the laser.
- 1 5. The laser apparatus of claim 1, further including a linear polarizer disposed between
2 the laser and the quarter wave retarder plate.
- 1 6. The laser apparatus of claim 5, wherein the linear polarizer is adjacent a surface of the
2 quarter wave retarder plate that faces the laser.

1 7. The laser apparatus of claim 1, including a hermetically sealed housing in which the
2 laser is mounted, the housing having a window through which the emitted laser light is
3 transmitted;

4 wherein the quarter wave retarder plate is disposed to form part of the housing.

1 8. The laser apparatus of claim 7, further including a linear polarizer disposed between
2 the laser and the quarter wave retarder plate.

1 9. The laser apparatus of claim 8, wherein the linear polarizer is adjacent a surface of the
2 quarter wave retarder plate that faces the laser.

1 10. The laser apparatus of claim 9, further including a lens disposed between the laser and
2 the optical transmission system, wherein the quarter wave retarder plate is disposed between
3 the laser and the lens.

1 11. The laser apparatus of claim 1, including a hermetically sealed housing in which the
2 laser is mounted, wherein the quarter wave retarder plate is disposed to form a window of the
3 housing through which the emitted laser light is transmitted.

1 12. The laser apparatus of claim 11, further including a linear polarizer disposed between
2 the laser and the quarter wave retarder plate.

1 13. The laser apparatus of claim 12, wherein the linear polarizer is adjacent a surface of
2 the quarter wave retarder plate that faces the laser.

1 14. The laser apparatus of claim 1, further including a lens disposed between the laser and
2 the optical transmission system, wherein the quarter wave retarder plate is disposed between
3 the lens and the optical transmission system.

1 15. Laser apparatus for generating laser light to be transmitted through an optical
2 transmission system, comprising:

3 a laser that emits light that is substantially linearly polarized;

4 a hermetically sealed housing in which the laser is mounted, the housing having a
5 window through which the emitted laser light is transmitted; and

6 a quarter wave retarder plate, disposed with respect to the laser so that the emitted
7 laser light passes through the quarter wave retarder plate prior to transmission of the emitted
8 laser light through the optical transmission system, the quarter wave retarder plate causing the
9 emitted laser light to become circularly polarized with a predefined handedness;

10 wherein the quarter wave retarder plate is also disposed so that light reflected by the
11 optical transmission system back toward the laser passes through the quarter wave retarder
12 plate prior to reaching the laser, the quarter wave retarder plate causing the reflected light to
13 become linearly polarized with a polarization that is orthogonal to the emitted laser light
14 emitted by the laser.

1 16. The laser apparatus of claim 15, further including a lens disposed between the laser
2 housing and the optical transmission system, wherein the quarter wave retarder plate is
3 disposed between the housing and the lens.

1 17. The laser apparatus of claim 16, further including a linear polarizer disposed between
2 the quarter wave retarder plate and the housing.

1 18. The laser apparatus of claim 17, wherein the linear polarizer is adjacent a surface of
2 the quarter wave retarder plate that faces the laser.

1 19. The laser apparatus of claim 15, further including a linear polarizer disposed between
2 the quarter wave retarder plate and the housing.

1 20. The laser apparatus of claim 19, wherein the linear polarizer is adjacent a surface of
2 the quarter wave retarder plate that faces the laser.

1 21. The laser apparatus of claim 15, wherein the quarter wave retarder plate is disposed to
2 form part of the housing.

1 22. The laser apparatus of claim 21, further including a linear polarizer disposed between
2 the quarter wave retarder plate and the laser.

1 23. The laser apparatus of claim 15, further including a lens disposed between the laser
2 housing and the optical transmission system, wherein the quarter wave retarder plate is
3 disposed between the lens and the optical transmission system.

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FIBER OPTIC LASER TRANSMITTER WITH
REDUCED NEAR END REFLECTIONS

5

ABSTRACT OF THE DISCLOSURE

10 A laser apparatus, which generates laser light to be transmitted through an optical
transmission system includes a laser that emits light that is substantially linearly polarized, a
housing in which the laser is mounted, and a quarter wave retarder plate. The quarter wave
retarder plate is disposed so that the emitted laser light passes through the quarter wave
retarder plate prior to transmission of the emitted laser light through the optical transmission
system. The quarter wave retarder plate causing the emitted laser light to become circularly
15 polarized with a predefined handedness. The quarter wave retarder plate is also disposed so
that light reflected by the optical transmission system back toward the laser passes through
the quarter wave retarder plate a second time prior to reaching the laser, causing the reflected
light to become linearly polarized with a linear polarization that is orthogonal to the
polarization state of the light emitted by the laser. In one embodiment, a linear polarizer is
20 positioned adjacent a front face of the quarter wave retarder plate. The linear polarizer
imposes a particular linear polarization orientation on the emitted laser light, and blocks the
reflected light that passes through the quarter wave retarder plate because that light has a
linear polarization that is orthogonal to the polarization axis of the linear polarizer.

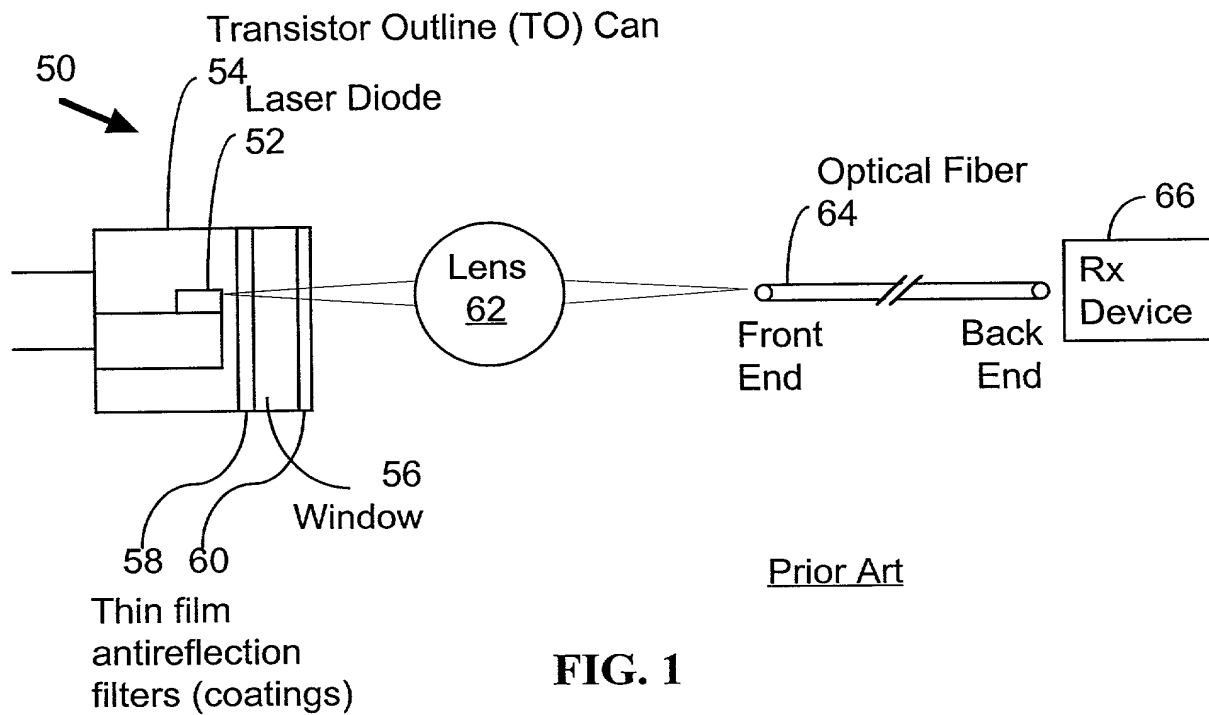


FIG. 1

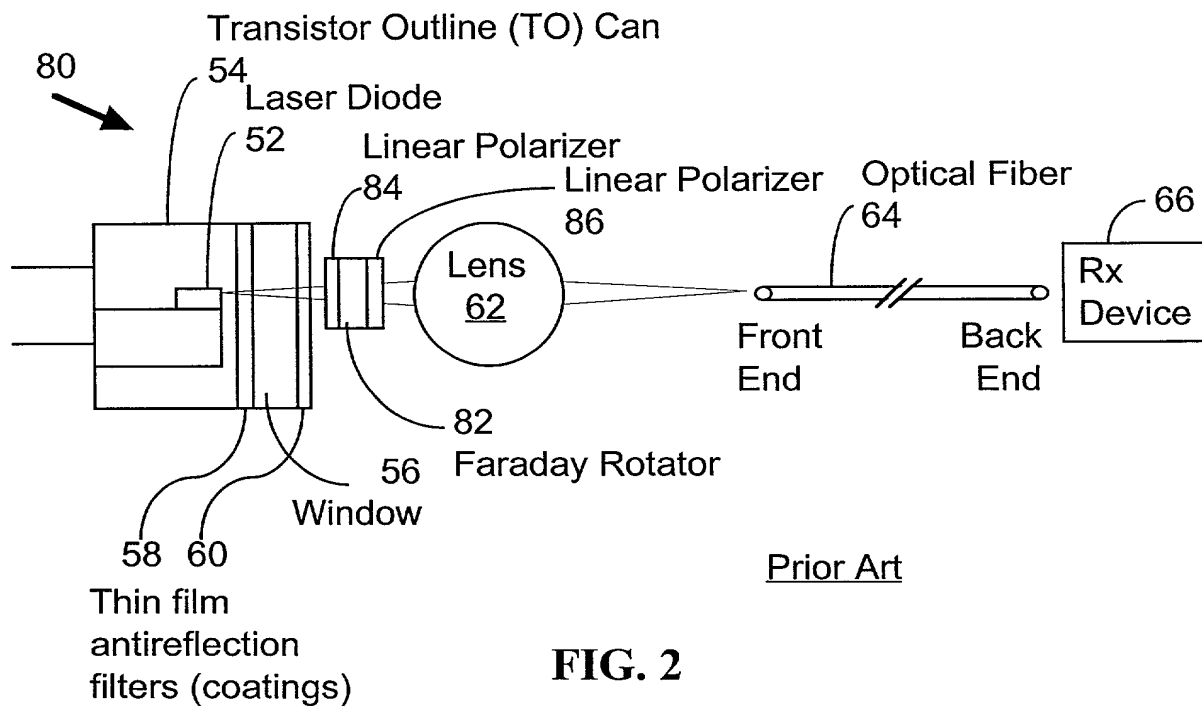
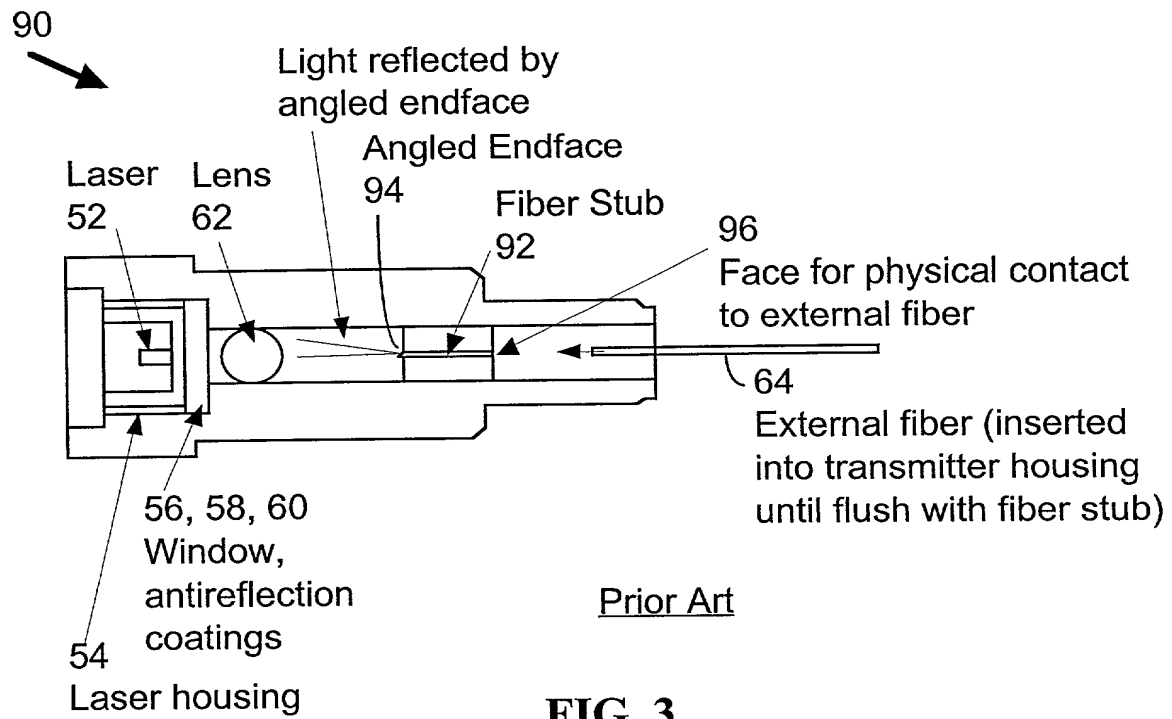
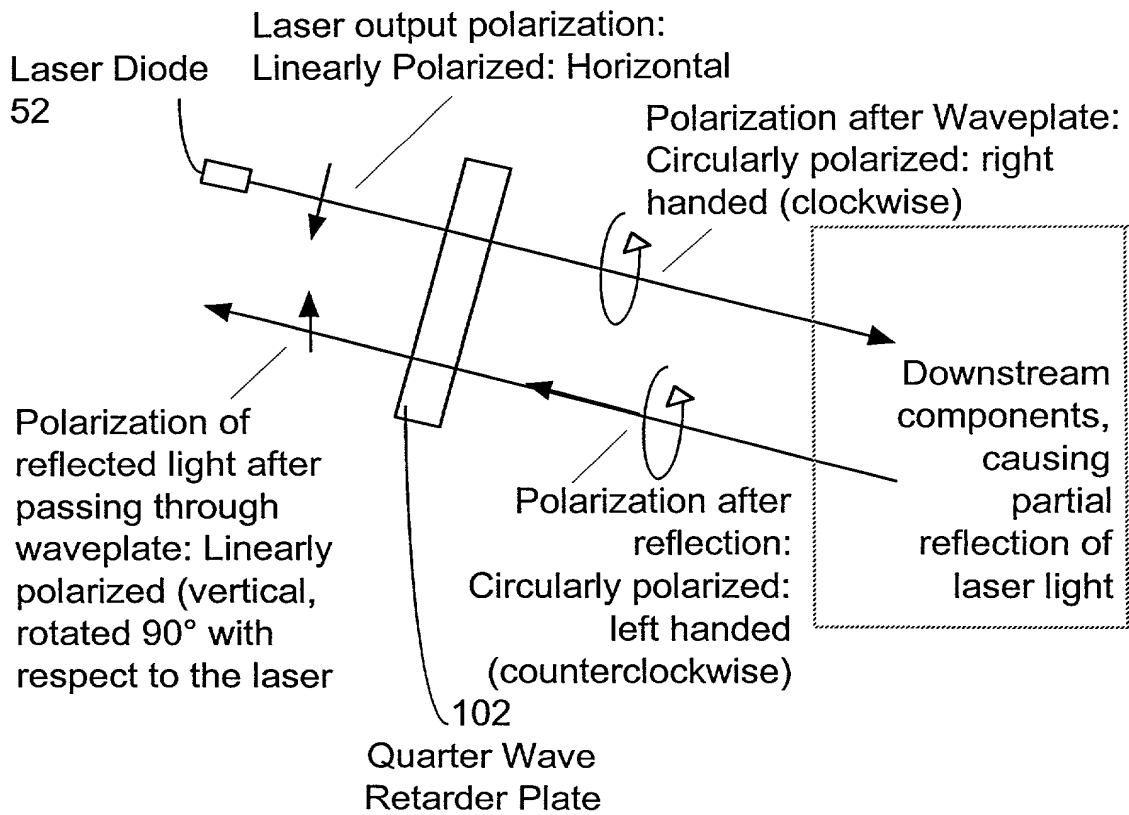
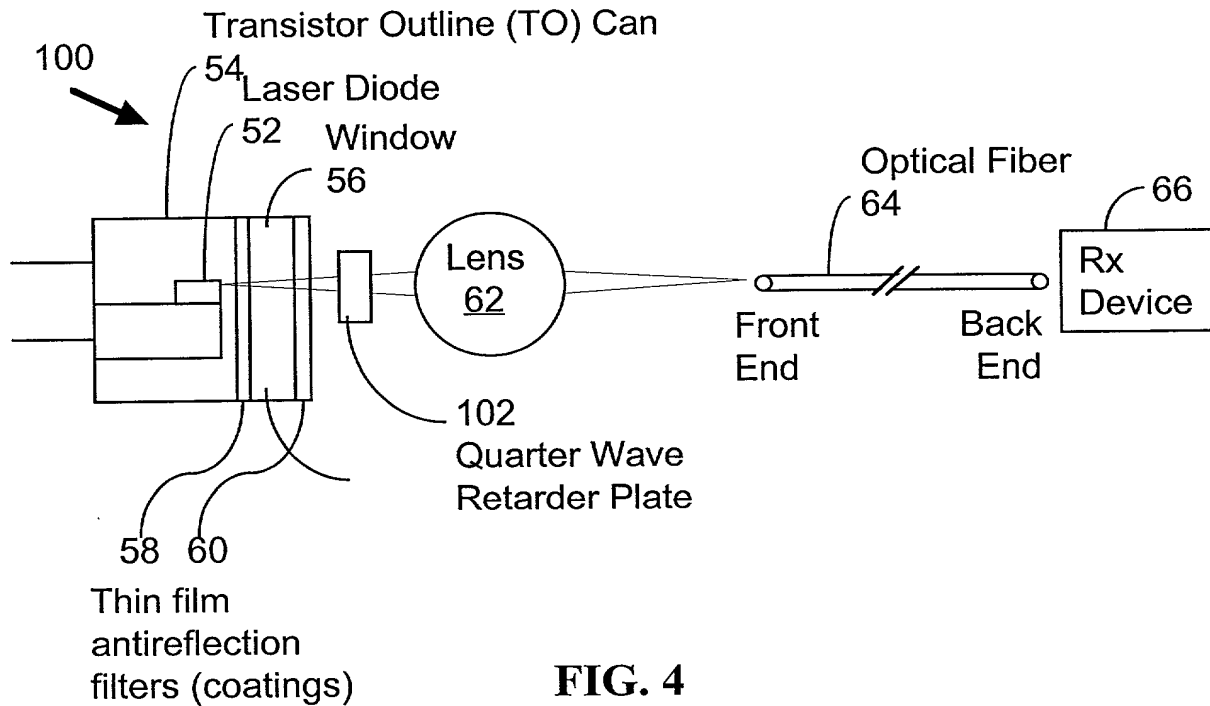
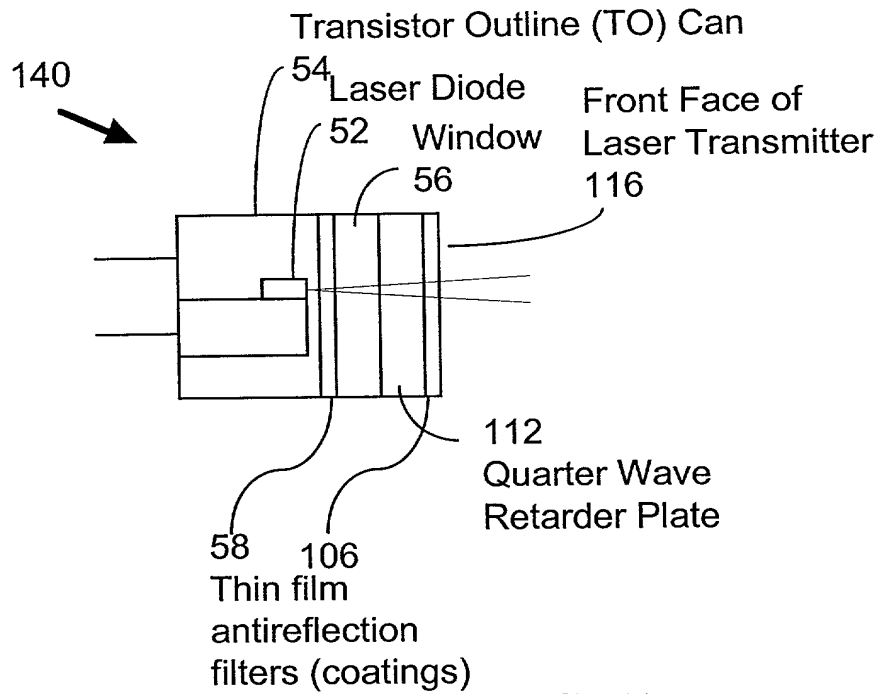
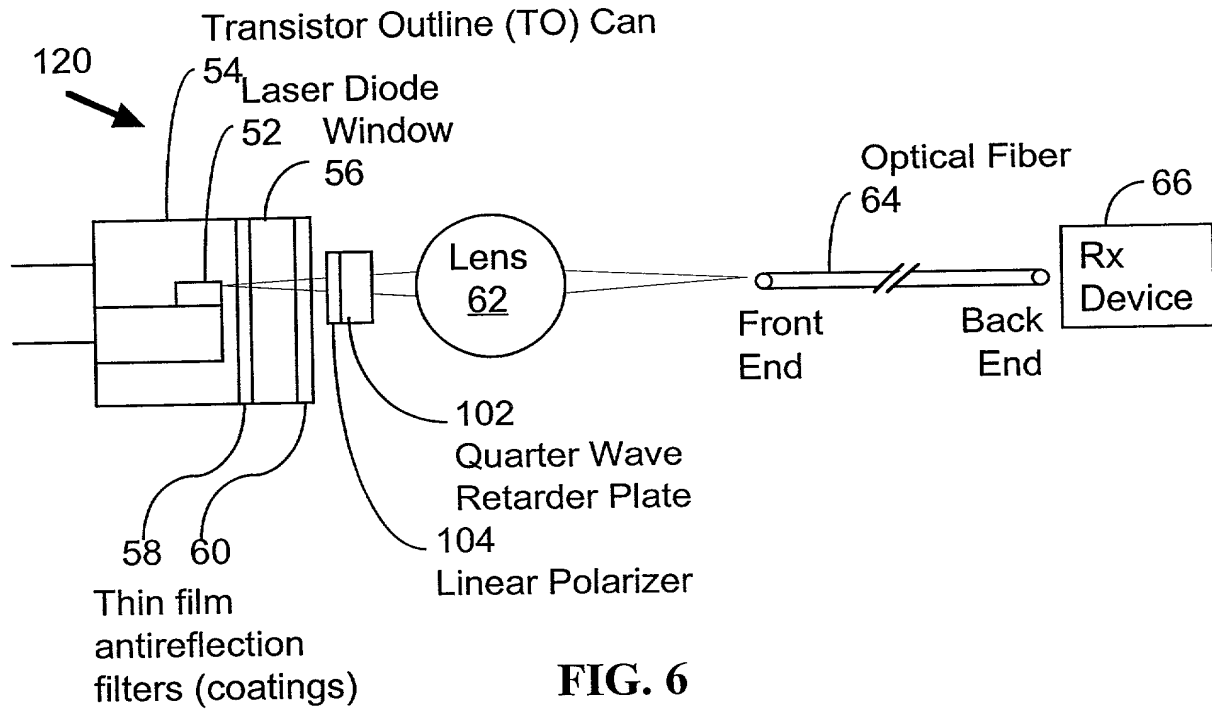


FIG. 2







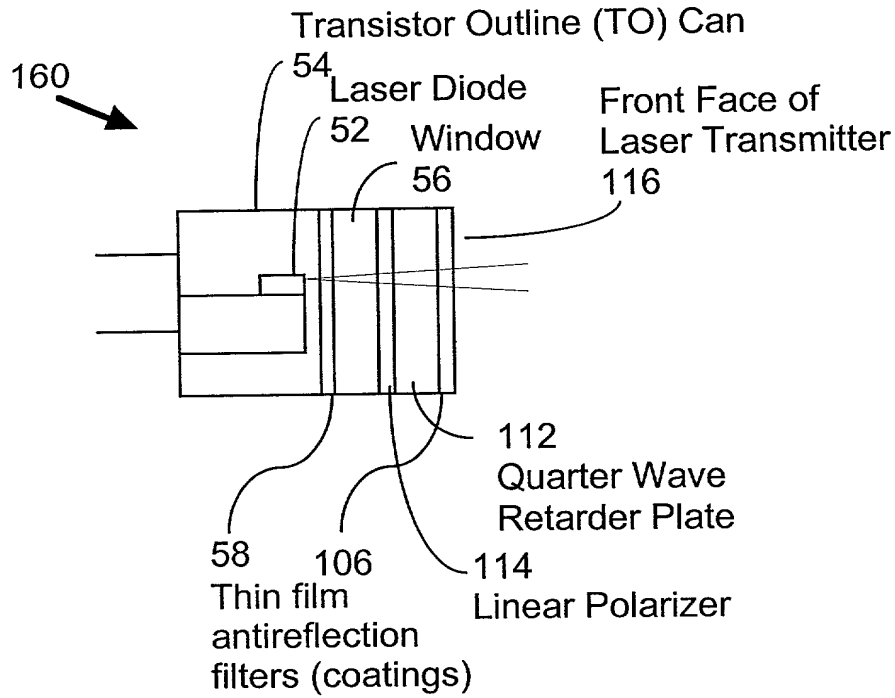


FIG. 7B

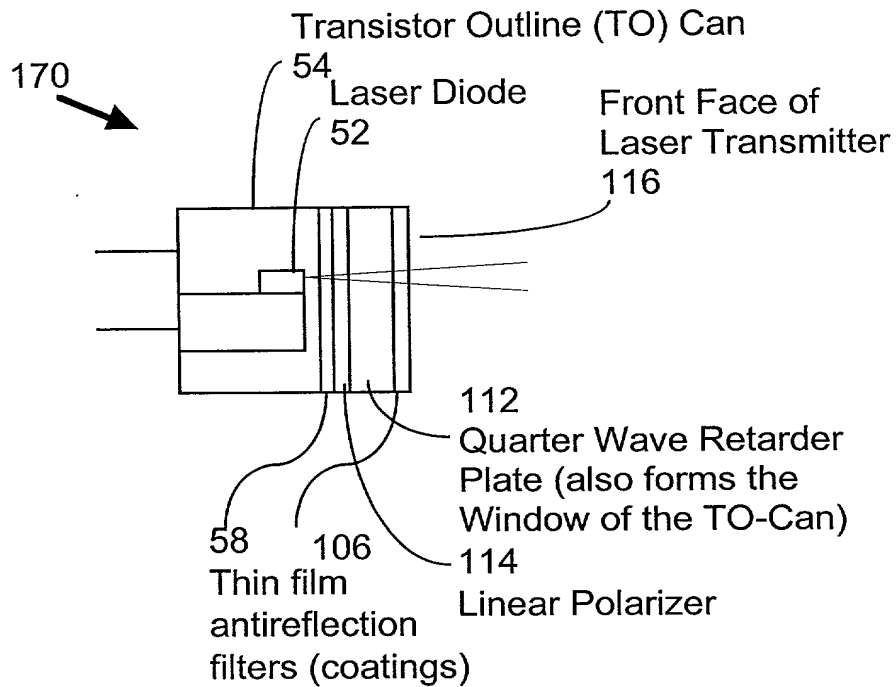
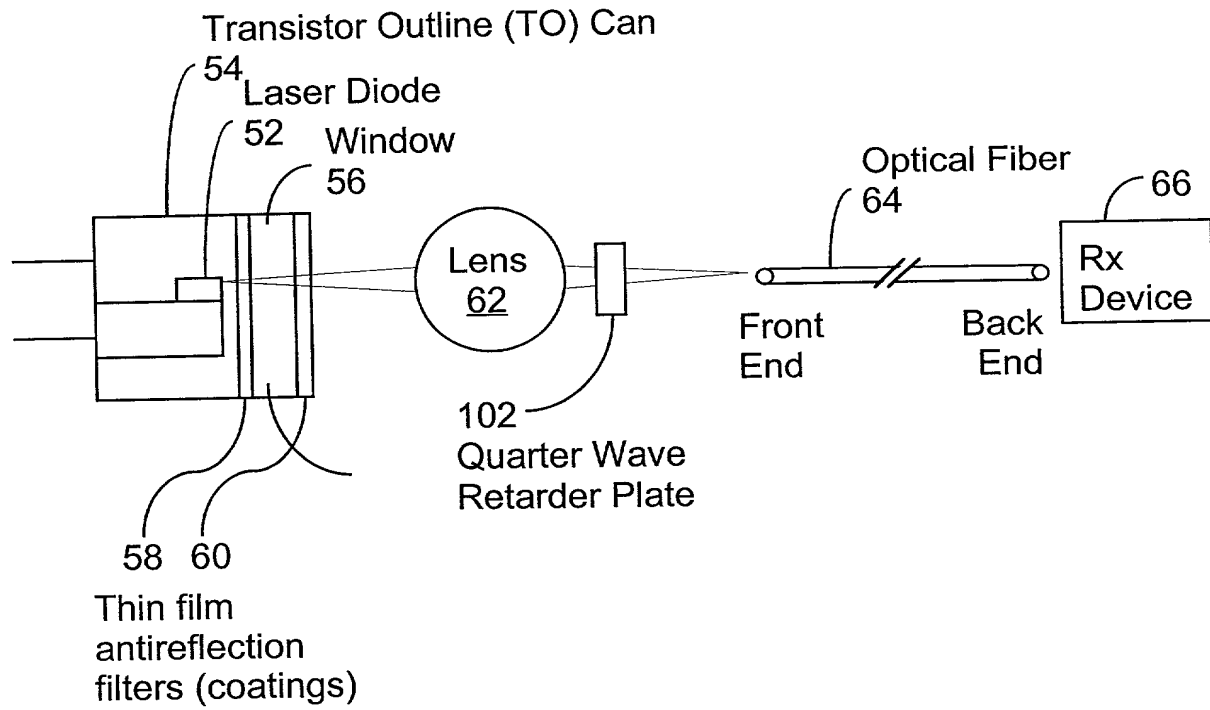


FIG. 7C

**FIG. 7D**

DECLARATION FOR PATENT APPLICATION

As a below-named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled FIBER OPTIC LASER TRANSMITTER WITH REDUCED NEAR END REFLECTIONS, the specification of which

(check one) XX is attached hereto.

_____ was filed on _____ as
Application Serial No. _____
and was amended on _____
(if applicable)

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a).

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s)			Priority Claimed	
(Number)	(Country)	(Day/Month/Year Filed)	Yes	No
_____	_____	_____	_____	_____
(Number)	(Country)	(Day/Month/Year Filed)	Yes	No

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulation, §1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

_____	_____	_____
(Application Serial No.)	(Filing Date)	(Status)
		(patented, pending, abandoned)
_____	_____	_____
(Application Serial No.)	(Filing Date)	(Status)
		(patented, pending, abandoned)
_____	_____	_____
(Application Serial No.)	(Filing Date)	(Status)
		patented, pending, abandoned)

Variable	Mean	Standard deviation	Minimum	Maximum	Skewness	Kurtosis	Jarque-Bera	Probability
Return	0.0000	0.0100	-0.0500	0.0500	0.0000	3.0000	0.0541	0.8154
Volatility	0.0100	0.0050	0.0000	0.0200	0.0000	3.0000	0.0541	0.8154
Correlation	0.0000	0.0100	-0.0500	0.0500	0.0000	3.0000	0.0541	0.8154
Information ratio	0.0000	0.0100	-0.0500	0.0500	0.0000	3.0000	0.0541	0.8154
Tracking error	0.0000	0.0100	-0.0500	0.0500	0.0000	3.0000	0.0541	0.8154
Alpha	0.0000	0.0100	-0.0500	0.0500	0.0000	3.0000	0.0541	0.8154
Beta	0.0000	0.0100	-0.0500	0.0500	0.0000	3.0000	0.0541	0.8154
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Epsilon	0.0000	0.0100	-0.0500	0.0500	0.0000	3.0000	0.0541	0.8154
Zeta	0.0000	0.0100	-0.0500	0.0500	0.0000	3.0000	0.0541	0.8154
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Iota	0.0000	0.0100	-0.0500	0.0500	0.0000	3.0000	0.0541	0.8154
Kappa	0.0000	0.0100	-0.0500	0.0500	0.0000	3.0000	0.0541	0.8154
Lambda	0.0000	0.0100	-0.0500	0.0500	0.0000	3.0000	0.0541	0.8154
Mu	0.0000	0.0100	-0.0500	0.0500	0.0000	3.0000	0.0541	0.8154
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Xi	0.0000	0.0100	-0.0500	0.0500	0.0000	3.0000	0.0541	0.8154
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Pi	0.0000	0.0100	-0.0500	0.0500	0.0000	3.0000	0.0541	0.8154
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Sigma	0.0000	0.0100	-0.0500	0.0500	0.0000	3.0000	0.0541	0.8154
Tau	0.0000	0.0100	-0.0500	0.0500	0.0000	3.0000	0.0541	0.8154
Upsilon	0.0000	0.0100	-0.0500	0.0500	0.0000	3.0000	0.0541	0.8154
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Chi	0.0000	0.0100	-0.0500	0.0500	0.0000	3.0000	0.0541	0.8154
Psi	0.0000	0.0100	-0.0500	0.0500	0.0000	3.0000	0.0541	0.8154
Omega	0.0000	0.0100	-0.0500	0.0500	0.0000	3.0000	0.0541	0.8154

PENNIE & EDMONDS LLP
3300 Hillview Avenue
Palo Alto, California 94304

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Title 18, United States Code, §1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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POWER OF ATTORNEY BY ASSIGNEE
AND CERTIFICATE UNDER 37 CFR 3.73(b)

To the Commissioner of Patents:

The undersigned assignee of the entire interest in application for letters patent entitled : FIBER OPTIC LASER TRANSMITTER WITH REDUCED NEAR END REFLECTIONS, and having the named inventors: Lewis B. Aronson and Daniel S. Kane, hereby appoints the following attorneys to transact all business in the Patent Office connected therewith: S. Leslie Misrock (Reg. No. 18872), Harry C. Jones, III (Reg. No. 20280), Berj A. Terzian (Reg. No. 20060), David Weild, III (Reg. No. 21094), Jonathan A. Marshall (Reg. No. 24614), Barry D. Rein (Reg. No. 22411), Stanton T. Lawrence, III (Reg. No. 25736), Charles E. McKenney (Reg. No. 22795), Philip T. Shannon (Reg. No. 24278), Francis E. Morris (Reg. No. 24615), Charles E. Miller (Reg. No. 24576), Gidon D. Stern (Reg. No. 27469), John J. Lauter, Jr. (Reg. No. 27814), Brian M. Poissant (Reg. No. 28462), Brian D. Coggio (Reg. No. 27624), Rory J. Radding (Reg. No. 28749), Stephen J. Harbulak (Reg. No. 29166), Donald J. Goodell (Reg. No. 19766), James N. Palik (Reg. No. 25510), Thomas E. Friebe (Reg. No. 29258), Laura A. Coruzzi (Reg. No. 30742), Jennifer Gordon (Reg. No. 30753), Allan A. Fanucci (Reg. No. 30256), Geraldine F. Baldwin (Reg. No. 31232), Victor N. Balancia (Reg. No. 31231), Samuel B. Abrams (Reg. No. 30605), Steven I. Wallach (Reg. No. 35402), Marcia H. Sundeen (Reg. No. 30893), Paul J. Zegger (Reg. No. 33821), Edmond R. Bannon (Reg. No. 32110), Bruce J. Barker (Reg. No. 33291), Adriane M. Antler (Reg. No. 32605), Thomas G. Rowan (Reg. No. 34419), James G. Markey (Reg. No. 31636), Thomas D. Kohler (Reg. No. 32797), Scott D. Stimpson (Reg. No. 33607), Gary S. Williams (Reg. No. 31066), William S. Galliani (Reg. No. 33885), Ann L. Gisolfi (Reg. No. 31956), Todd A. Wagner (Reg. No. 35399), Scott B. Familant (Reg. No. 35514), Kelly D. Talcott (Reg. No. 39582), Francis D. Cerrito (Reg. No. 38100), Anthony M. Insogna (Reg. No. 35203), Brian M. Rothery (Reg. No. 35340), Brian D. Siff (Reg. No. 35679), and Alan Tenenbaum (Reg. No. 34939), all of **Pennie & Edmonds LLP**, whose addresses are 1155 Avenue of the Americas, New York, New York 10036, 1667 K Street N.W., Washington, DC 20006 and 3300 Hillview Avenue, Palo Alto, CA 94304, to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith.

In accordance with 37 CFR 3.73 the assignee hereby certifies that it is the assignee of the entire right, title and interest in the patent application identified above by virtue of an Assignment from the inventors. Said assignment being filed in the Patent and Trademark Office together with the application. The undersigned has reviewed all the documents in the chain of title of the patent application identified above and, to the best of undersigned's knowledge and belief, title is in the assignee identified below.

The undersigned hereby declares that all statements made herein of his own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Title 18, United States Code, 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

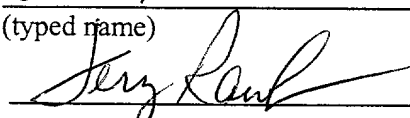
Direct all telephone calls to GARY S. WILLIAMS at (650) 493-4935.

Address all correspondence to:

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FINISAR CORPORATION

By: JERRY RAWLS
(typed name)

Signature: 

Title: Chief Executive Officer
Address: 1308 Moffet Park Drive
Sunnyvale, CA 94089-1133

Date: March 7, 2000

File No. 9775-0031-999